



ECONOMIC RESEARCH
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WORKING PAPER SERIES

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Working Paper Number	1982-004B
Revision Date	January 1982
Citable Link	https://doi.org/10.20955/wp.1982.004
Suggested Citation	Hafer, R.W., 1982; The Monetary Base or M1? Results from a Small Macromodel, Federal Reserve Bank of St. Louis Working Paper 1982-004. URL https://doi.org/10.20955/wp.1982.004

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INTRODUCTION

A question of continuing interest to monetary policymakers concerns the choice of the appropriate intermediate target for the conduct of policy.^{1/} In choosing the intermediate target, two important questions must be addressed: First, how well does the variable project the future path of economic activity? Second, to what degree can the Federal Reserve control the intermediate target variable?

Previous analyses have focused on examining the first of these two concerns because there is substantial evidence that the growth of the narrow definition of money (M1) is better related to monetary base (hereafter base) growth than is the broader M2 money measure. Also, M1 has been shown to be statistically superior to M2 in explaining GNP growth.^{2/} Thus, the general conclusion is that M1 is preferred to M2 as an intermediate target.

Some have argued that, because of slippages (control errors) between the base and M1 via the multiplier, the Fed should focus on controlling base growth. One study, by Andersen and Karnosky [2], showed that as far as predicting nominal GNP growth is concerned, there is no statistical difference between the results obtained from using base, M1 or M2. Fama [6] has argued recently that control of

base growth gives a more direct control over inflation than does controlling the monetary aggregates. In addition, Fama shows that base growth is not related to the growth of real GNP, whereas M1 growth is. The resulting policy scenario suggested by Fama is that controlling base, not M1, will lead to better control of inflation while not affecting real GNP growth.

Most empirical analyses have focused solely on the money-GNP link to investigate the relative properties of base and M1 in explaining economic activity. The procedure followed in this paper is to compare the relative merits of base and M1 in a small macroeconomic model consisting of a nominal GNP and inflation specification. The comparison of the base and M1 equations is done on several statistical criteria: In-sample predictive performance, stability and out-of-sample predictive performance. The next section presents the model and the in-sample estimates using base and M1. Section III examines the question of stability and out-of-sample performance. Concluding remarks are presented in Section IV.

SECTION II: THE MODEL AND IN-SAMPLE RESULTS

The model used in this paper is based on Tatom [17]. This model consists of a St. Louis-type reduced form nominal GNP equation that accounts for energy price effects, and an inflation equation that is based on Karnosky [14] with energy price effects incorporated. Real GNP is determined implicitly as the difference between the nominal GNP growth and inflation estimates. The model, then, consists of the following specifications:

$$(1) \dot{Y}_t = a_0 + \beta_1 \sum_{i=0}^n m_{t-i} \dot{M}_{t-i} + \beta_2 \sum_{j=0}^m e_{t-j} \dot{E}_{t-j} \\ + \sum_{k=0}^L \beta_{3,k} \dot{p}_{t-k}^e + \beta_4 S_t + \epsilon_t$$

and

$$(2) \dot{P}_t = \alpha_1 + \delta_1 \sum_{i=0}^n m_{t-i} \dot{M}_{t-i} + \sum_{j=1}^m \delta_{2,j} \dot{p}_{t-j}^e \\ + \delta_3 D1 + \delta_4 D2 + \eta_t$$

where

- Y = nominal GNP
- M = the money measure; base or M1
- E = high-employment federal expenditures
- p^e = relative price of energy^{3/}
- S = strike variable^{4/}
- P = GNP deflator (1972=100)

and D1, D2 = dummy variables for price control periods^{5/}.

The dot (.) above the variables denotes annual rate of change,
 ϵ_t and η_t are error terms.

Equations (1) and (2) are estimated using ordinary least squares (OLS), unlike previous estimations that have relied on the Almon lag estimation procedure. The reason for this choice is the continued uncertainty that is associated with applying, a priori, the numerous restrictions incorporated in the Almon technique. Although one may test for these restrictions individually, i.e., degree of polynomial, lag length and endpoint restriction, one cannot test for them jointly. Thus our use of OLS estimates.^{6/} In estimating equations (1) and (2), we have used the basic format provided in Tatom [17] since preliminary examinations of various lag lengths for M1 or base did not alter the results.

unity. The relevant t-statistics for the M1 measure is 0.65 and for base it is 0.91, each well below and acceptable critical level. Irrespective of the monetary definition, the fiscal variable shows no lasting or significant effect on GNP growth.

One result of changing the monetary definitions is the reduction in the number of lagged energy price coefficients: A contemporaneous and five lagged terms are used in the M1 equation and only three lagged terms are used in the base equation. This change gives the relative price of energy a larger negative influence (-0.16) in the base equation relative to the effect in the M1 version (-0.02).

Similar to previous studies, the outcome of comparing the statistical properties of equations (3) and (4) is to favor the equation employing M1 to explain movements in nominal GNP growth. This is apparent in the superiority of equation (3)'s \bar{R}^2 to that of equation (4): Using M1 yields about a 27 percent improvement in explanatory power over the equation using base growth.

Next we compare the 1960/I-1980/IV estimates of inflation (equation 2) using M1 and the base. These results are (absolute value of t-statistics in parentheses)

$$(5) \dot{P}_t = 0.934 \sum_{i=0}^{20} m_{t-i} \dot{M}_{t-i} + 0.013 \dot{P}_{t-1}^e + 0.0418 \dot{P}_{t-2}^e \\ (20.57) \quad (0.74) \quad (1.95) \\ - 0.031 \dot{P}_{t-3}^e + 0.062 \dot{P}_{t-4}^e - 1.918 D1 + 1.134 D2 \\ (1.23) \quad (3.29) \quad (3.38) \quad (2.11) \\ \bar{R}^2 = 0.814 \quad SE = 1.214 \quad DW = 1.75$$

and

$$(6) \dot{P}_t = 0.854 \sum_{i=0}^{20} b_{t-i} \dot{B}_{t-i} + 0.030 \dot{P}_{t-1}^e + 0.035 \dot{P}_{t-2}^e \\ (22.40) \quad (0.61) \quad (1.51)$$

$$- 0.012 \dot{p}_{t-3}^e + 0.021 \dot{p}_{t-4}^e - 1.976 D1 + 1.800 D2$$

(0.54) (1.15) (3.08) (2.91)

$$\bar{R}^2 = 0.779$$

$$SE = 1.321$$

$$DW = 1.51$$

Comparison of these results once again suggests the preference of M1 over base, ceteris paribus, in explaining movements in inflation. Changing the definition of the monetary variable leads to some alterations in the individual energy price coefficients as well as the dummy variables. The most striking and important difference is found in the relative cumulative impact of M1 and base on inflation. We cannot reject the hypothesis that the sum coefficient on M1 does not differ from its theoretical value of unity ($t = 1.45$) at the 5 percent level of significance. The sum coefficient on the base variable, however, is statistically different from unity at the 1 percent level of significance ($t = 3.83$). Assuming that the lag structures are being measured appropriately, this result suggests that a 1 percentage point increase in the base growth rate will, after 5 years, result in only a 0.85 percentage point increase in inflation while the same increase in M1 will lead to an equivalent rise in inflation. Looking at the summary statistics, the inflation estimates indicate that, as with the GNP equations, M1 growth is preferable to base growth in explaining movements of inflation during the 1960/I-1980/IV period.

SECTION III: STABILITY TESTS AND FORECASTING RESULTS

If one were to choose between base and M1 at this stage, the evidence presented thus far would favor selecting M1. Such a decision, based on parameter estimates for a 20-year sample period,

may be based on unstable parameter estimates. To examine the stability properties of equations (3)-(6), the sample period was split at 1970/II.^{8/}

Stability Tests

The subperiod estimates for the GNP and inflation equations are presented in tables 1 and 2, respectively. Looking first at the M1-GNP equations, there appears to be significant changes in the estimated coefficients across the two subperiods. This is especially true for the summed coefficient on the high-employment federal expenditure variable and several of the lag coefficients on the energy price variable. The general statistical insignificance of these variables during each sub-period suggests, however, that these differences will have little impact on the overall stability of the equation. Even the summed coefficient on M1 indicates a slight increase during the second subperiod. This increase is, however, within the confidence region of the first subperiod estimate. Indeed, testing the stability of the overall relationship between M1 growth and GNP growth using the Chow test yields an F-statistic of $F(18,48) = 0.40$, less than the critical value at the 5 percent level of significance.

Turning next to the base/GNP equations, the findings reported in table 1 indicate a substantial shift in the estimated coefficients on the cumulative impact of base growth on GNP growth. For example, during the period 1960/I-1970/II, the estimated sum coefficient for base is 0.96. This is compared to the 1970/III-1980/IV estimate of 2.20 --a value over twice the size of the previous period estimate and significantly different from unity at the 5 percent level. The sum coefficient on the fiscal variable

displays a marked change, increasing almost sevenfold between the two subperiods. Moreover, the sum coefficient on the fiscal actions measure achieves statistical significance (at the 10 percent level) during the 1970s. Again using the Chow test, we formally tested for structural stability of the base/GNP relationship. Interestingly, the resulting F-value, $F(18,48) = 1.46$, does exceed the 5 percent critical value. Thus, we cannot reject the hypothesis of stability. This result is somewhat surprising, given the rather large deviation in the sum coefficients. To investigate the stability of the base-GNP relationship more closely, the following test was used: lagged base growth terms were dummied out for each subperiod. This equation was estimated for the 1960/I-1980/IV period and compared by means of an F-test to the full period regression results reported in the text. In this way, we can statistically assess the usefulness of dichotomizing the effects of base growth across the two periods. The result of the comparison is an F-statistic of $F(5,61) = 0.72$, a value well below any acceptable significance level. Thus, although the sum coefficients for base in table 1 appear to be quite different, statistically we cannot reject the notion that, as a group, they are the same.

The inflation subperiod results reported in table 2. Interestingly, the cumulative impact of M1 and base growth on inflation are statistically the same during each subperiod. For example, during the period I/1960-II/1970, the sum coefficient on M1 is 0.942 ($t = 9.38$) while the sum coefficient for M1 across the 1970/II-1980/IV period is 0.972 ($t = 11.82$). This evidence suggests a stable relationship between M1 and inflation across the full sample period,

ceteris paribus. Indeed, the results from the Chow test support this contention: The calculated F-value of $F(27,30) = 1.33$ is well below the relevant 5 percent critical value. Thus, like the M1/GNP relationship, the M1/inflation specification is stable across the 1960/I-1980/IV sample period.

The base-inflation results presented in table 2 indicate that there is only a small change in the cumulative effects of base growth on inflation across the two periods. For example, the sum coefficient for the 1960/I-1970/II period is 0.848 ($t=11.51$) while the value of the coefficient declines in the 1970/III-1980/IV period is 0.749 ($t=10.88$). In each instance, the estimated coefficients are statistically different from unity. The relatively minor changes in the base coefficients, clearly the most statistically important variable in explaining movements in inflation suggest that the overall relationship will be stable. The results of the Chow test support this notion: The calculated F-value $F=(27,30) = 0.80$ is less than the 5 percent critical value. Thus, as with M1, we cannot reject the stability hypothesis.

Forecast Results

To further analyze the relative merits of base and M1, the following experiment was conducted. The respective GNP and inflation specifications were estimated from 1960/I to 1970/IV and four-period-ahead forecasts were made. The estimation period then was extended through 1971/IV and forecasts were made for the four quarters of 1972. This procedure was continued until forecasts for the year 1980 were obtained. The averages of the quarterly projections, along with summary statistics, are presented in table 3.

The first two columns of table 3 report the forecast performances for the GNP equation using base and M1. Over the 10 years reported, M1 betters the base forecast 60 percent of the time. Moreover, the record using base suggests a slight underprediction, on average, of GNP growth while M1 indicates that, on average, the forecast error is essentially zero (0.04 percentage points). Compared to base, M1 improves the average GNP forecasting performance almost five times. The summary statistics also reveal that M1 is better in predicting GNP growth than in base: the root-mean-squared error (RMSE) for M1 is 4.12 or about 10 percent lower than the 4.52 RMSE for base. Moreover, the Theil U-statistic indicates that the average performance of M1 growth in predicting GNP growth is superior to that of base.

The third and fourth columns of table 3 present the inflation forecasting records for the two monetary aggregates. Here the overall performances are much closer than with GNP. Still, M1 growth provides a smaller forecast error in 7 of the 10 years studied in addition to an average error that is less than half the average error using base growth. The differences in the RMSE and Theil U statistics suggest that there may be only marginal differences between the capabilities of the two measures in predicting inflation, on average. It is interesting to note, however, that during the 1974-1980 period of rapid inflation, the M1 forecast errors are about 2 percentage points, on average, less than those from the base equation. Moreover, while the M1 equation slightly overpredicted inflation from 1974 to 1980 (0.02 percentage points), the base equation yielded inflation predictions that were less than actual inflation (1.95 percentage points).

SECTION IV: CONCLUSION

The perennial question that monetary policymakers and their economic advisors must address is "Which variable should be used as an intermediate target?" In this paper, we have examined the estimation, stability and forecasting properties of base and M1 in a small, reduced-form macroeconomic model which consists of a nominal GNP growth equation and an inflation specification. The M1 measure provided better in-sample results for both GNP growth and inflation regressions. M1 was also the better measure in predicting GNP growth from 1970 to 1980. Thus, from the test results presented in this study, the evidence indicates that M1 is preferred as the intermediate target variable over the base measure.

FOOTNOTES

- 1/ To resolve any conflict with our use of the terminology, the intermediate target variable is that which reflects a policy action designed to ultimately influence the path of economic activity. For a useful collection on this subject, see Brunner [3]. Also, see Friedman [8,9].
- 2/ These two aspects are discussed in Hafer [12]. See also Schadrack [16], Levin [15], Hamburger [13], Carlson and Hein [4], GAMBS [10], and Davis [5].
- 3/ The relative price of energy variable is constructed by deflating the private business sector energy price component by the GNP deflator.
- 4/ The strike variable is used to capture the impact on GNP growth due to days of work loss. The variable is constructed as the change in the quarterly average of days lost due to strikes deflated by the civilian labor force. See Tatom [17] and Andersen [1] for further discussion of this variable.
- 5/ The dummy variables are used to capture the influence of the imposition and subsequent removal of wage and price controls. Specifically, $D1=1$ for 1971/III-I/1973, 0 otherwise and $D2=1$ for I/1973-I/1975, 0 otherwise. Thus, $D1$ is used to represent the control period and $D2$ is used to capture the impact of the energy price controls. See Tatom [17], especially fn. 14.
- 6/ For a previous examination of this type of equation using OLS, see Carlson and Hein [4].
- 7/ All regressions reported in this paper use the adjusted monetary base as defined by the Federal Reserve Bank of St. Louis and the new M1 measure. The cumulative statistics for the monetary measures and fiscal actions are derived by estimating a version of equation (1) where the longest lag is subtracted from each of the other variables. Thus, for example, $M1_{t-4}$ is subtracted from $M1_{t-i}$ ($i = 0,1,2,3$). The estimated OLS coefficient on the last lag ($M1_{t-4}$) is the estimate of the cumulative effect. I would like to thank Scott Hein for pointing this out to me. Test results presented in this paper using the Almon lag technique are available from the author upon request.
- 8/ Stability tests necessarily involve a degree of arbitrariness in selecting the hypothesized break point. The selection of 1970/II--the mid-point of the sample-- was done to maximize the power of the Chow test. On this point, see Farley, Hinich and McGuire [7].

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Table 1
Subperiod Estimates for Equation (1) ^{1/}

Variable	1960/I-1970/II		1970/III-1980/IV	
	Base	MI	Base	MI
Constant	2.31 (1.92)	3.98 (3.66)	-9.85 (1.72)	-1.63 (0.46)
$\sum_{i=0}^4 m_i$	0.955 (3.42)	1.142 (3.31)	2.191 (2.99)	1.361 (2.92)
$\sum_{i=0}^4 e_i$	-0.069 (0.66)	-0.130 (1.03)	0.453 (1.87)	0.269 (0.96)
\dot{p}_t^e	0.134 (1.23)	-0.038 (0.28)	-0.070 (1.47)	-0.052 (1.10)
\dot{p}_{t-1}^e	-0.097 (0.92)	0.031 (0.27)	0.027 (0.46)	0.095 (1.55)
\dot{p}_{t-2}^e	-0.181 (1.75)	-0.059 (0.54)	0.037 (0.64)	0.026 (0.42)
\dot{p}_{t-3}^e	0.089 (0.82)	0.060 (0.56)	-0.197 (4.21)	-0.073 (1.11)
\dot{p}_{t-4}^e		0.265 (2.40)		-0.042 (0.66)
\dot{p}_{t-5}^e		0.136 (1.20)		0.079 (1.38)
S_t	-0.695 (2.54)	-0.159 (0.58)	-0.767 (2.48)	-0.636 (2.08)
\bar{R}^2	0.468	0.479	0.460	0.469
SE	2.345	2.320	3.018	2.992
DW	1.65	1.46	2.71	2.46

^{1/} Absolute value of t-statistics appear in parentheses. \bar{R}^2 is the adjusted coefficient of determination, SE is the regression standard error and DW is the Durbin-Watson test statistic. All equations use an Almon polynomial lag structure for the monetary and fiscal variables.

Table 2
Subperiod Estimates for Equation (2) ^{2/}

Variable	1960/I-1970/II		1970/III-1980/IV	
	Base	MI	Base	MI
$\sum_{i=0}^{20} \dot{p}_{t-i}^m$	0.848 (11.51)	0.942 (9.38)	0.749 (10.88)	0.972 (11.82)
\dot{p}_{t-1}^e	-0.034 (0.64)	-0.128 (2.04)	0.004 (0.12)	0.004 (0.13)
\dot{p}_{t-2}^e	0.010 (0.21)	0.013 (1.69)	0.059 (1.48)	0.030 (0.73)
\dot{p}_{t-3}^e	-0.093 (1.91)	-0.138 (2.00)	-0.011 (0.28)	-0.034 (0.94)
\dot{p}_{t-4}^e	0.032 (0.65)	0.032 (0.47)	0.035 (1.04)	0.073 (2.65)
D1			-3.621 (3.18)	-3.190 (4.02)
D2			-1.568 (1.06)	1.355 (2.10)
\bar{R}^2	0.671	0.737	0.504	0.681
SE	1.002	0.896	1.593	1.278
DW	1.65	1.40	1.91	2.19

^{1/} Absolute value of t-statistics appear in parentheses. \bar{R}^2 , SE and DW are defined in notes to table 1. All equations are estimated using an Almon polynomial lag on the monetary variables, third degree, with far end constrained.

Table 3
Post-Sample Prediction Errors for
GNP and Inflation ^{1/}

Period	GNP		Inflation	
	Base	M1	Base	M1
1971	3.07	1.62	-0.79	-0.76
1972	-1.48	-0.16	0.04	0.03
1973	-4.74	-4.60	-2.01	-1.36
1974	2.07	2.52	-1.34	-2.31
1975	4.99	3.56	1.20	1.96
1976	-0.10	-0.53	2.31	1.61
1977	-2.37	-1.23	0.92	0.27
1978	-1.37	-1.69	-1.58	-2.10
1979	-0.11	1.12	-1.17	-0.08
1980	-1.85	-0.18	-2.30	0.67
ME	-0.19	0.04	-0.47	-0.21
RMSE	4.52	4.12	2.02	2.04
U	0.46	0.41	0.30	0.30

^{1/} Errors reported are four quarter averages for years shown, actual less predicted. ME is the mean error, RMSE is the root mean squared error and U is the Theil U Statistic.